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THE PROSPECTS FOR GEOGRAPHIC DIVERSIFICATION IN UK REGIONAL PROPERTY INVESTMENT: IMPLICATIONS DERIVED FROM MULTIVARIATE COINTEGRATION ANALYSIS

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ABSTRACT

This paper examines the short and long-term comovements among UK regional property markets over the period 1976-2001. The markets examined are London, Outer South-East, East Anglia, South West, East Midlands, West Midlands, Yorkshire and Humberside, North and North West. Multivariate cointegration procedures, Granger non-causality tests, level VAR and generalised variance decomposition analyses based on error-correction and vector autoregressive models are conducted to analyse short and long-run relationships among these markets. The results indicate that there is a stationary long-run relationship and significant long-run causal linkages between the various UK property markets. In terms of the percentage of variance explained other regional markets are generally more important than innovations in a given region, though this is not the case for the Outer South-East which is extremely segmented from the remaining markets, as is, to a lesser extent, the North and North West. This suggests that opportunities exist for portfolio diversification in UK regional property market.

Keywords: Regional property markets, Portfolio diversification, Short and long-run relationships

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INTRODUCTION

Diversification is a dominant theme in the property investment literature. If, and as has been hypothesised, low correlations of returns exist; diversifying across various categories of property investment may allow investors to reduce portfolio risk while holding expected return constant. However, despite the obvious importance of this body of thought to portfolio managers, the application of the central tenets of Markowitz portfolio theory to the property market is comparatively recent, with the original focus on property's role in a mixed asset portfolio. More lately, emphasis has moved to investigating the implications of portfolio theory within the property portfolio itself.

As discussed, the first strand of empirical endeavour has concerned itself with the optimal allocation of property in a 'mixed asset' portfolio, encompassing property, bonds, bills and stocks. Lins et al. (1992), Kalberg et al. (1996), Liu and Jianping (1998), Rubens et al. (1998), Gordon et al (1998), Giliberto et al. (1999), Chandrashekaran (1999) and Tuluca et al. (2000) have recently examined the prospects for diversification for mixed asset portfolios that include a property component. This work has generally concurred with Chandrashekaran's (1999: 111) finding that property investment "…appears to offer significant diversification benefits, at least during certain time periods".

An extension of this work has used the notion of mixed asset portfolio diversification to obtain the optimal country allocation of property investment. De Wit (1997), Eichholtz et al. (1998), Wilson and Okunev (1999), Quan and Titman (1999), Cheng et al. (1999), Stevenson (2000) and Eichholtz et al. (2001) have all drawn upon the central tenets of Markowitz portfolio theory in this manner. In contrast to the work on domestic mixed asset portfolios, the evidence concerning global property investment is less conclusive. Cheng et al. (1999: 463), for example, found that "our results suggest that although foreign real estate is not likely to provide investors with significant diversification benefits, substantial amounts of foreign real estate can be optimal". Alternatively, Eichholtz et al. (2001: 365) countered the "trade-off between the costs and benefits of international diversification" with the suggestion that "…the costs for property investors can be reduced substantially through investments in public real estate securities, which concentrate on their local domestic market". Lizieri and Finlay

(1995) provide a useful overview of some of the many pertinent issues in international property portfolio iversification.

The second strand of empirical endeavour has examined ‘within property’ portfolio diversification by property type and/or geographic region. Recent studies in this area include Hartzell et al. (1986), Eichholtz et al. (1995), Graff and Young (1996), Williams (1996), Sivitanides (1996), Hoesli et al. (1997), Wolverton et al (1998), Cheng and Black (1998), Viezer (2000), Byrne and Lee (2000) and Brown et al. (2000). The evidence concerning within property diversification is also somewhat mixed. For instance, in a study of UK sectors and regions Byrne and Lee (2000: 23) concluded, “…risk reduction is limited because of the high positive correlations between assets in any portfolio. Conversely, Viezer (2000: 94) found that “in support of the main body of real estate research, economic diversification was found to be superior to geographic diversification” and that “MPT-efficient portfolios provide considerably higher expected returns than naïve (equal weighted) portfolios”. Seiler et al. (1999) provides a useful review of the literature concerning the diversification benefits of property in both mixed asset and within property portfolios.

Notwithstanding the evidence concerning whether property should be included in mixed asset portfolios, or whether property portfolios should be extended internationally, or how property portfolios should be diversified regionally or by property type, most of this work fails to analyse the price indices of the different asset classes as part of a cointegrated system of individually nonstationary series. This is important because the cointegration of price series for different assets has several implications, not least for asset diversification but also for price discovery or predictability of returns (Tuluca et al. 2000).

First, it is well known that Markowitz proved that low correlations are necessary for diversification. However, when asset prices are cointegrated [such that there is some tendency in the long run for two or more series not to drift too far apart (or move together)] then the benefits of correlation may be less than that implied by correlation alone because zero-order correlation coefficients will underestimate the long-run relationships between asset classes. Second, cointegration of asset price series may also affect the analysis of the dynamic relationships among these assets. For example, the price discovery process that establishes causal flows from one or more assets classes to another may be misspecified, resulting in the spurious forecasting of prices. It is then important to ascertain the cointegration (or lack thereof) for price series under investigation. If the series are cointegrated, it is possible to increase the accuracy of previous results by including the long-run relationships in the study of returns. Accordingly, the purpose of the present paper is to add evidence to the nascent debate on cointegration between property markets.

The remainder of the paper is divided into four main areas. The first section explains the data employed in the present analysis, while the second section discusses the methodology employed. The results are dealt with in the third section. The paper ends with some brief concluding remarks.

DATA AND DESCRIPTIVE STATISTICS

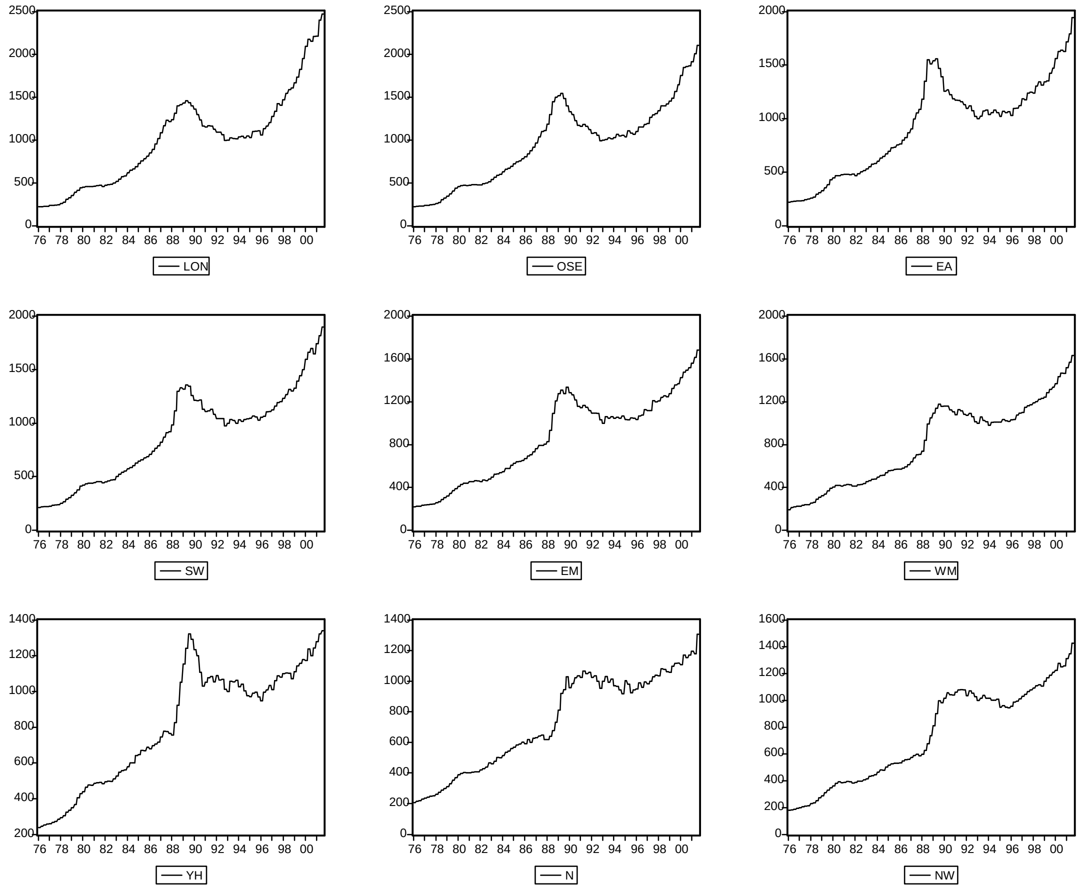
The data employed in the study is composed of indices for nine regional property markets in the United Kingdom. All property index data is obtained from the Nationwide Building Society and encompasses the period January 1976 to September 2001. All quarterly index data are specified in Pound Stirling. Selected descriptive statistics of the annualised returns for these property indexes are presented in Table 1. The index series themselves are featured in Figure 1 and the quarterly returns calculated using these indexes are depicted in Figure 2.

	LON	OSE	EA	SW	EM	WM	YH	N	NW
Mean	4.0478	3.7641	3.6480	3.6596	3.4206	3.5814	2.8784	3.0713	3.4571
Median	4.3766	4.0274	3.7441	3.3459	3.1404	3.1487	2.8986	2.5548	2.6799
Maximum	13.4520	13.4969	14.4235	16.0064	17.6813	17.2385	13.8354	14.7311	12.4055
Minimum	-7.9617	-7.7693	-7.1022	-4.6681	-6.2523	-2.8189	-9.8761	-4.5393	-2.8029
Standard deviation	4.9423	5.0394	5.0861	4.8259	4.5369	4.2649	4.5231	3.9293	3.8008
Skewness	-0.3624	-0.1698	0.1535	0.5485	0.8788	1.3649	-0.1947	0.7061	0.7900
Kurtosis	3.1933	3.1369	3.1747	3.5311	5.6425	5.4760	4.8522	4.8026	3.2070
CV	1.2210	1.3388	1.3942	1.3187	1.3263	1.1908	1.5714	1.2794	1.0994
Jarque-Bera	0.6097	0.1452	0.1351	1.6094	10.9115	14.7136	3.8809	5.6807	2.7509
JB *p*-value	0.7372	0.9300	0.9347	0.4472	0.0043	0.0006	0.1436	0.0584	0.2527

Notes: LON – London, OSE – Outer South-East, EA – East Anglia, EM – East Midlands, WM - West Midlands, YH – Yorkshire and Humberside, N – North, NW – North West.

Table I.
Selected descriptive statistics of UK property returns, 1976-2001

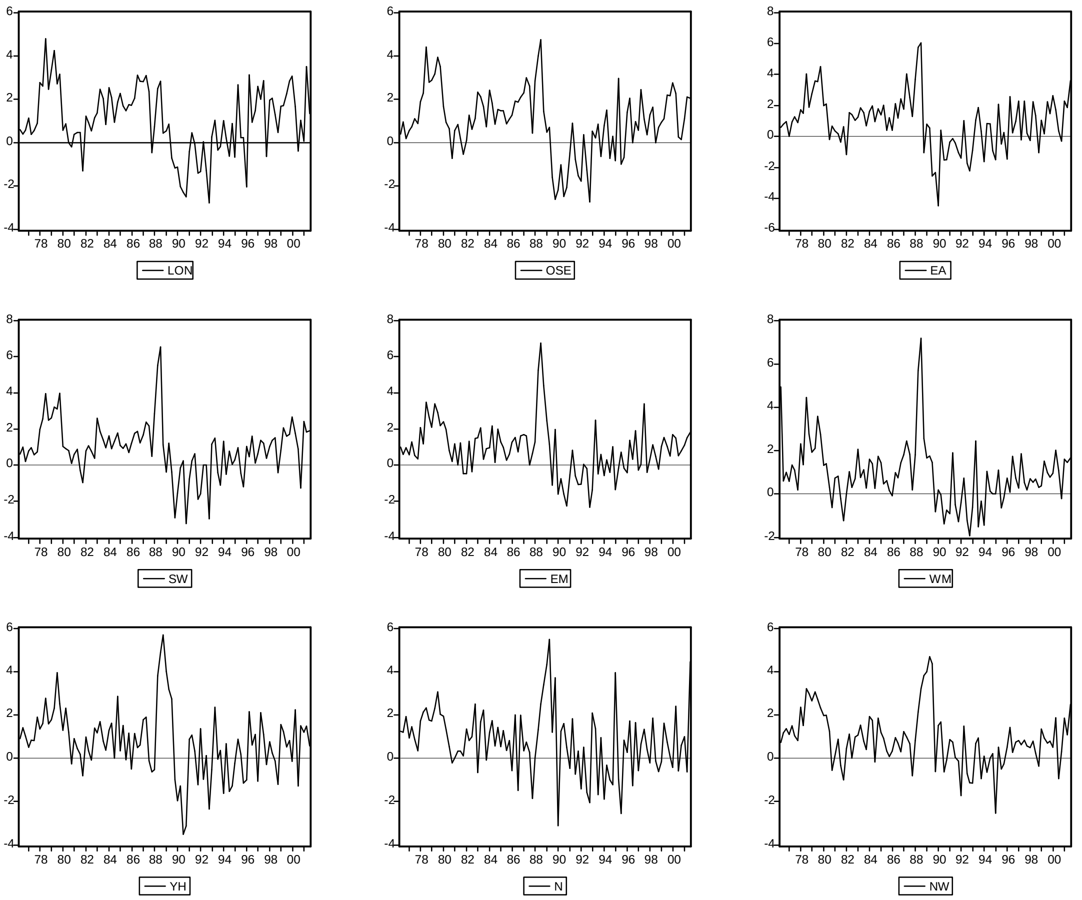
The nine major UK property indexes are specified as follows: (i) London (LON), (ii) Outer South East (OSE) (iii) East Anglia (EA) (iv) South West (SW) (v) East Midlands (EM) (vi) West Midlands (WM) (vii) Yorkshire and Humberside (YH) (viii) North (N) and (ix) North West (NW). The indexes selected are consistent with other studies in the area of property investment returns and risk in the UK such as Byrne and Lee (2000).



Notes: LON – London, OSE – Outer South-East, EA – East Anglia, EM – East Midlands, WM - West Midlands, YH – Yorkshire and Humberside, N – North, NW – North West.

Figure I.
Quarterly UK property series by region, 1976-2001

In common with most work in this area, the figures in Table I show that the mean annual returns on the outer regional property markets are generally lower than those surrounding London, irrespective of risk. Over the period 1976 to 2001 the highest annual property returns were 4.05 percent for London, 3.76 percent for Outer South-East and 3.66 percent for South-West markets and the lowest annual returns were 3.42 percent for East Midlands, 3.07 percent for North and 2.88 percent for Yorkshire and Humberside. Conforming to theoretical expectations, the risk (as measured by standard deviation) is consequently much higher for regional markets surrounding London, while the risk diminishes for those markets furthest from London. For example, the standard deviation of annual returns for the London property index was 4.94 percent which is slightly lower than the most risky property market, Outer South-East, with a standard deviation of 5.04 percent and the least risky property market was North-West with a standard deviation of 3.80 percent. The value of the coefficient of variation (standard deviation divided by the mean return) measures the degree of risk in relation to the mean return. The coefficients of variation for the nine UK regions are fairly consistent ranging from 1.09 (North-West) to 1.57 (Yorkshire and Humberside). Markets with a higher coefficient of variation (more risk per unit of return) include Outer South East (OSE), East Anglia (EA) and Yorkshire and Humberside (YH) ranging from 1.34 to 1.57. UK property markets with lower coefficients of variation include North West (NW), West Midlands (WM) and London (LON). The coefficients of variation for this last group of property markets range between 1.09 and 1.28.



Notes: LON – London, OSE – Outer South-East, EA – East Anglia, EM – East Midlands, WM - West Midlands, YH – Yorkshire and Humberside, N – North, NW – North West.

Figure II.
Quarterly UK property returns by region, 1976-2001

The quarterly returns associated with these indices are depicted in Figure 2. All of the UK property returns series are volatile, and most of the UK property markets have periods of sustained negative returns corresponding to the period 1989-1992. Visual examination of the UK property returns also indicates a strong cyclical pattern and this appears to be shared by most of the markets in question. Returns are generally positive in the period 1976-

1988, negative from 1989-1996, positive from 1985 to 1991, negative from 1992 to 1996, and positive thereafter. All the return series with the exception of West Midlands (WM) and East Midlands (EM) fail to reject the null hypothesis of a normal distribution of returns according to the Jarque-Bera statistic (Table 1).

EMPIRICAL METHODOLOGY

The paper investigates the comovements among UK regional property markets as follows. To start with, since the variance of a nonstationary series is not constant over time, conventional asymptotic theory cannot be applied for those series. Unit root tests of the null hypothesis of nonstationarity are conducted in the form of an Augmented Dickey-Fuller (ADF) regression equation:

$$\Delta Y_{it} = a_0 + a_1 t + r_0 Y_{it-1} + \sum_{i=1}^{p} r_i \Delta Y_{it-i} + e_{it} \qquad (1)$$

where Y_{it} denotes the index for the i-th market at time t, $\Delta Y_{it} = Y_{it} - Y_{it-1}$, r are coefficients to be estimated, p is the number of lagged terms, t is the trend term, a_1 is the estimated coefficient for the trend, a_0 is the constant, and e is white noise. The critical values in MacKinnon (1991) are used in order to determine the significance of the test statistic associated with r_0. ADF tests are performed on both the levels and first differences of the indices. Where each index is nonstationary in levels and stationary in first differences, it may be concluded that the indices are individually integrated of order 1, I(1). An important property of I(1) variables is that there can be a linear combination of these variables that are I(0) (stationary). If this is so, then these variables are cointegrated such that there is some tendency for the two series in the long run not to drift too far apart (or move together).

Following Engle and Granger (1987) suppose we have a set of m indices $y_t = [Y_{1t,} Y_{2t}, \Lambda, Y_{mt}]'$ such that all are I(1) and $b' y_t = u_t$ is I(0), then b is said to be a cointegrated vector and $b' y_t = u_t$ is called the cointegrating regression. The components of y_t are said to be cointegrated of order d,b denoted by y_t ~ CI(d, b) where $d > b > 0$, if (i) each component of y_t is integrated of order d,b and (ii) there exists at least one vector $b = (b_1, b_2, \ldots, b_m)$, such that the linear combination is integrated of (d - b). By Granger's theorem, if the indices are cointegrated, they can be expressed in an Error Correction Model (ECM) encompassing the notion of a long-run equilibrium relationship and the introduction of past disequilibrium as explanatory variables in the dynamic behaviour of current variables. This model thus allows a test for both short-term and long-term relationships between the indices. The ECM is specified as follows:

$$\Delta y_t = a_0 + \Pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + e_t \qquad (2)$$

where , $\Pi = ab'$, a and b are $m \times r$ matrices, r is the cointegrating rank, Γ_i is the coefficients of the lagged difference terms, and all other variables are as previously defined. In (2) the long-run relationship is captured by $b' y_t$, and the differenced terms and the terms that are adjusted by the long-run relationship (the summation term on the right-hand side) capture the short-run relationship.

In order to implement the ECM, the order of cointegration must be known. A useful statistical test for determining the cointegrating rank r is proposed by Johansen (1991) and Johansen and Juselius (1990). The test is based on the MLE and the rank of Π (denoted by r) is tested based on its eigenvalues. The trace test is proposed. In the trace test, the test statistic is:

$$l(r) = -T \sum_{i=r+1}^{m} \ln(1 - l_i) \qquad (3)$$

where T is the number of useable observations, l_i is the eigenvalues of $| lS_{kk} - S_{k0} S_{00}^{-1} S_{0i} | = 0$ and $\hat{\Pi}$ is the estimator of the coefficient matrix of error correction terms. The test statistic (3) tests the null hypothesis of the number of distinct cointegrating vectors as $r = 0$ versus $r > 0$, $r \leq 1$ versus $r > 1$, and so on. For example, to test for no cointegrating relationship, r is set to zero and the null hypothesis is $H_0 : r = 0$ and the alternative is $H_1 : r > 0$.

One potential problem is that the Johansen (1991) test can be affected by the lag order in (2). The lag order is determined by using the likelihood ratio (LR) test. The optimum number of lags to be used in the VAR models is determined by the likelihood ratio (LR) test statistic:

$$LR = (T - K)\ln\left(|\Sigma_0| / |\Sigma_A|\right) \tag{4}$$

where T is the number of observations, K denotes the number of restrictions, Σ denotes the determinant of the covariance matrix of the error term, and subscripts *0* and *A* denote the restricted and unrestricted VAR, respectively. LR is asymptotically distributed c^2 with degrees of freedom equal to the number of restrictions. The test statistic in (4) is used to test the null hypothesis of the number of lags being equal to $k - 1$ against the alternative hypotheses that k = 2, 3, … and so on. The test procedure continues until the null hypothesis fails to be rejected, thereby indicating the optimal lag corresponds to the lag of the null hypothesis.

These cointegration tests examine long-run causality among the nine regional property markets. In order to examine the short-run relationships, Granger (1969) non-causality tests are specified. Essentially tests of the prediction ability of time series models, an index causes another index in the Granger sense if past values of the first index explain the second, but past values of the second index do not explain the first. If the indices in question are cointegrated, Granger non-causality is tested using the ECM:

$$\Delta y_t = g_0 + \sum_{i=1}^{r} y_i \Theta_{t-1} + \sum_{i=1}^{m} g_i \Delta y_{t-i} + e_t \tag{5}$$

where Θ contains r individual error-correction terms, r is the number of long-term cointegrating vectors via the Johansen procedure, y and g are parameters to be estimated, and all other variables are as previously defined. If there is no cointegrated relationship, the causality tests are conducted using the following VAR model:

$$\Delta y_t = g_0 + \sum_{i=1}^{m} g_i \Delta y_{t-i} + e_t\ . \tag{6}$$

In both cases, the causality test is based on an *F*-statistic that is calculated using the constrained and unconstrained form of each equation. If the hypothesis $g_{ijl} = 0\,(i = 1,2,\Lambda\ , m)$ fails to be rejected the *l*-th index does not Granger cause the *j*-th index, and current changes in *j*-th index cannot be explained by changes in the *l*-th index. If the hypothesis is rejected, the *l*-th index Granger-causes the *j*-th index and current changes in the *j*-th index can be explained by past changes in the *l*-th index, thereby indicating a casual relationship.

One problem with a Granger non-causality test based on (5) is that it is affected by the specification of the model. ECM is estimated under the assumption of a certain number of lags and cointegrating equations, which means that the actual specification thereby depends on the pre-test unit root (ADF) and cointegration (Johansen) tests. To avoid possible pre-test bias, Toda and Yamamoto (1995) propose the level VAR procedure. Essentially, the level VAR procedure is based on VAR for the level of variables with the lag order p in the VAR equations given by $p=k+d_{max}$, where k is the true lag length and d_{max} is the possible maximum integration order of variables. The estimated VAR is expressed as:

$$y_t = \hat{g}_0 + \hat{g}_1 t + \Lambda + \hat{g}_q t^q + \hat{J}_1 y_{t-1} + \Lambda + \hat{J}_k y_{t-k} + \Lambda + \hat{J}_p y_{t-p} + \hat{e}_t\,, \tag{7}$$

where $t = 1, \ldots, T$ is the trend term and $\hat{g}_i, \hat{J}_j$ are parameters estimated by OLS. Note that d_{max} does not exceed the true lag length k. Equation (7) can be written as:

$$Y' = \hat{\Gamma}\Lambda + \hat{\Phi}X + \hat{\Psi}Z' + \hat{\mathrm{E}}' \tag{8}$$

where $\hat{\Gamma} = (\hat{g}_0, \mathrm{K}, \hat{g}_q)$, $\Lambda = (t_1, \mathrm{K}, t_T)$ with $t_t = (1, t, , \mathrm{K}, t^q)'$, $\hat{\Phi} = (\hat{J}_1, \mathrm{K}, \hat{J}_k)$, $\hat{\Psi} = (\hat{J}_{k+1}, \mathrm{K}, \hat{J}_p)$, $X = (x_1, \Lambda, x_T)$ with $x_t = (y'_{t-1}, \mathrm{K}, y'_{t-k})'$, $Z = (z_1, \Lambda, z_T)$ with $z_t = (y'_{t-k-1}, \mathrm{K}, y'_{t-p})'$ and $\hat{E}' = (\hat{e}_1, \mathrm{K}, \hat{e}_T)$. As restrictions in parameters, the null hypothesis $H_0 : f(f) = 0$ where $f = vec(\Phi)$ is tested by a Wald statistic defined as:

$$W = f(\hat{f})' \left[F(\hat{f}) \left\{ \hat{\Sigma}_e \otimes (X'QX)^{-1} \right\} F(\hat{f})' \right]^{-1} f(\hat{f}) \qquad (9)$$

where $F(f) = \partial f(f) / \partial f', \hat{\Sigma}_e = T^{-1} \hat{E}' \hat{E},\ Q = \hat{Q}_t - \hat{Q}_t Z (Z' \hat{Q}_t Z)^{-1} Z' \hat{Q}_t$ and $\hat{Q}_t = I_T - \hat{\Lambda}(\hat{\Lambda}'\hat{\Lambda})^{-1} \hat{\Lambda}'$ where I_T is a $T \times T$ identity matrix. Under the null hypothesis, the Wald statistic (9) has an asymptotic chi-square distribution with m degrees of freedom that corresponds to the number of restrictions. Although Toda and Yamamoto (1995) and Masih and Masih (1999) present this method principally for the purpose of Granger non-causality testing, tests based on level VAR equations can also be used to examine long-run relationships. Test results based on the ECM can then be regarded as an indicator of short-run causality, while the causality tests by the level VAR can complement the result of the cointegration tests in terms of long-run information.

One final limitation of these tests is that while they indicate which regional markets Granger-cause another, they do not indicate whether yet other markets can influence a given market through other equations in the system. Likewise, Granger causality does not provide an indication of the dynamic properties of the system, nor does it allow the relative strength of the Granger-causal chain to be evaluated. However, decomposition of the variance of forecast errors of a given market allows the relative importance of other markets in causing fluctuations in that market to be ascertained. One likely problem is that the decomposition of variances is sensitive to both the assumed origin of the shock and to the order it is transmitted to other markets. That is, the results of the variance decomposition depend on the ordering of variables. One approach to this problem is to randomly order the variables a number of times and compare the results. Unfortunately, random ordering of nine indexes is neither practical nor sufficient to clearly highlight any disparities. The most realistic ordering criterion under these circumstances is to order markets by their effect to other markets: that is, in descending order of the number of causes in the causality tests.

EMPIRICAL RESULTS

Table II presents the ADF unit root tests (1) for the nine property indices in price level and price-differenced forms. In all instances, the null hypothesis of nonstationarity is tested. Analysis of the price levels series indicates non-stationarity for all of the property markets. However, all of the ADF test statistics are significant in first differenced form at the 0.01 level, indicating stationarity and the suggestion that each index series is integrated of order 1 or I(1). The finding of non-stationarity in levels and stationarity in first differences provides comparable property market evidence to Tuluca et al. (2000) and Wilson and Okunev (1999), though in both instances the property markets examined were national rather than regional.

Market		Level series	Differenced series
London	LON	-0.1449	-5.1524
Outer South-East	OSE	-1.2784	-4.1716
East Anglia	EA	-1.2532	-5.2595
South West	SW	-1.2250	-5.3174
East Midlands	EM	-1.6781	-5.3606
West Midlands	WM	-1.5841	-5.3871
Yorks and Humberside	YH	-2.2402	-5.5378
North	N	-1.6355	-8.1417
North West	NW	-1.5896	-5.7984
1% critical value		-3.9918	-3.4537
5% critical value		-3.4261	-2.8712
10% critical value		-3.1359	-2.5719

Notes: Hypotheses H_0: unit root, H_1: no unit root (stationary). The lag orders in the ADF equations are determined by the significance of the coefficient for the lagged terms. Intercepts and trends are included in the levels series, intercepts only in the first-differenced series.

Table II. Augmented Dickey-Fuller unit root tests

As discussed, Johansen cointegration trace tests are used to obtain the cointegrating rank. The likelihood ratio trace test statistics are included in Table III. As multivariate cointegration tests, the results cover all the included markets simultaneously rather than simple bivariate combinations. They therefore consider the wide range of portfolio diversification options available to investors, as well as the scope of market interrelationships that may not be reflected in pairwise combinations. Also included in Table III are critical values at the 0.05 level. For the period in question, the trace test statistics are greater than the critical values at the 0.05 level for the null hypotheses of $r = 0$ to $r = 4$ thereby rejecting the null hypothesis. However, the null hypothesis of $r \leq 5$ fails to be rejected in favour of $r > 5$ thereby indicating a cointegrating rank of 5. The primary finding obtained from the Johansen cointegration tests is that a stationary long-run relationship exists between all the UK property markets. That is, all nine series are cointegrated. Finding such cointegration between UK property markets is a nontrivial fact because it implies that, in the long run, the prices for various markets do not diverge and also that their short-run variations are influenced by this long-run equilibrium. Nevertheless, while the cointegrating relationship found is over the entire sample period, there may well have been sub-periods when the various series did diverge.

H_0	H_1	Trace test	5% critical value
r=0	r>0	355.1541	192.8900
r<=1	r>1	255.0572	156.0000
r<=2	r>2	177.0992	124.2400
r<=3	r>3	118.5518	94.1500
r<=4	r>4	76.2329	68.5200
r<=5	r>5	45.2675	47.2100
r<=6	r>6	23.9819	29.6800
r<=7	r>7	7.2728	15.4100
r<=8	r=9	2.9834	3.7600
Accepted number		5	

Notes: The optimal lag order of each VAR model was selected using the trace test for the significance of the coefficient for maximum lags and Schwarz's Bayesian Information Criterion (BIC). In each cointegrating equation, the intercept (no trend) is included.

Table III.
Cointegration tests

Since cointegration exists between the UK property indices, Granger non-causality tests are performed on the basis of the ECM in (5). *F*-statistics are calculated to test the null hypothesis that the first index series does not Granger-cause the second, against the alternative hypothesis that the first index Granger-causes the second. Calculated statistics and *p*-values for the various markets are detailed in Table IV. Among the nine markets, three significant causal links are found (at the 10 percent level or lower). For example, column 9 shows that the West Midland regional property markets affect the North West property market. The North West property market influences the market for properties in the Northern region. The Outer South-East property market Granger causes the properties in the South West region. It is evident that the UK regional property markets are not very influential upon each other in terms of Granger-causation in the short-run. Only three property markets, namely Outer South-East, West Midlands and North West, Granger cause other UK property markets.

	LON	OSE	EA	SW	EM	WM	YH	N	NW	Causes
LON	-	0.1345	0.0627	0.0067	1.3040	0.3292	2.3605	0.9150	0.0612	0
	-	(0.7141)	(0.8024)	(0.9347)	(0.2544)	(0.5666)	(0.1255)	(0.3396)	(0.8048)	
OSE	1.1628	-	2.2935	2.8300	2.2790	1.7762	0.9814	0.4149	0.0345	1
	(0.2818)	-	(0.1310)	(0.0936)	(0.1322)	(0.1836)	(0.3227)	(0.5200)	(0.8527)	
EA	0.0522	0.9453	-	0.6838	0.1705	0.4109	1.0204	0.7071	0.4427	0
	(0.8195)	(0.3317)	-	(0.4090)	(0.6800)	(0.5220)	(0.3132)	(0.4011)	(0.5064)	
SW	0.1471	0.2185	0.1342	-	0.0613	0.6539	0.1146	0.0080	0.6957	0
	(0.7016)	(0.6405)	(0.7144)	-	(0.8046)	(0.4194)	(0.7352)	(0.9288)	(0.4049)	
EM	1.0089	0.6490	1.2990	0.0849	-	0.0015	0.0329	0.0879	1.2174	0
	(0.3160)	(0.4211)	(0.2553)	(0.7710)	-	(0.9691)	(0.8562)	(0.7670)	(0.2708)	
WM	0.7400	0.5712	0.3343	0.3375	1.9392	-	1.5020	0.4206	4.3369	1
	(0.3903)	(0.4504)	(0.5635)	(0.5617)	(0.1648)	-	(0.2213)	(0.5172)	(0.0381)	
YH	0.1271	0.1148	0.0062	0.5976	0.8534	0.1076	-	0.0459	0.1874	0
	(0.7217)	(0.7350)	(0.9372)	(0.4401)	(0.3563)	(0.7431)	-	(0.8304)	(0.6654)	
N	0.6308	0.6949	0.0306	0.1116	0.1331	0.0441	0.0073	-	1.2131	0
	(0.4277)	(0.4052)	(0.8611)	(0.7385)	(0.7155)	(0.8339)	(0.9322)	-	(0.2716)	
NW	0.1886	0.7267	0.0599	0.0567	0.0086	0.1985	0.0153	4.8627	-	1
	(0.6644)	(0.3946)	(0.8068)	(0.8119)	(0.9260)	(0.6562)	(0.9016)	(0.0282)	-	
Caused	0	0	0	1	0	0	0	1	1	3

Notes: Granger causality tests are conducted by adjusting the long-term cointegrating relationship by the ECM. Figures in brackets are p-values. Tests indicate Granger causality by row to column and Granger caused by column to row. For example, Outer South-East (row) Granger-causes one property market (South West) and is Granger-caused by none (using a 10% critical value).

Table IV.
Short-run causality tests by ECM for English property markets, 1976-2001

One implication of the results in Table IV is that there may be no gains from pairwise portfolio diversification between those markets where a significant causal relationship exists; that is Outer South-East and South West, and West Midlands and the North. Also, with a finding of causality these markets must be seen as violating weak-form efficiency since one of the markets can help forecast the other. In all other cases, the absence of Granger causality implies that there are sufficient short-run differences between the markets for investors to gain by portfolio diversification. However, these results should consider that Granger causality only indicates the most significant direct causal relationship. For example, it may be that markets such as Outer South-East, which has only one significant causal link (with South West), may influence non-Granger caused markets indirectly through other markets. Likewise, some of the short-run interrelationships shown may well arise not from direct relationships between property markets and other markets, rather through the influence of markets that have not been included in the analysis. For example, it could well be that the global or continental property market exerts an influence on regional property markets in the UK. Equally likely are various measures of economic activity strongly associated with property markets including the rate of household formation and population growth, unemployment and GDP.

The long-run causality Wald test statistics and *p*-values based on Toda and Yamamoto’s (1995) level VAR procedure are presented in Table V. The model is estimated for the levels, such that a significant Wald test statistic indicates a long-term relationship. This serves to supplement the findings obtained from the Granger causality (short run) results in Table IV. Among the nine markets, nineteen significant causal links are found (at the 10 percent level or lower). This immediately suggests that there are many more significant causal links among UK property markets in the long run than in the short run. For example, column 4 shows that the Outer South-East, East Anglia and North West markets influence the South West market. This contrasts to the short run where the East Anglia and North West markets were not influential, though the Outer South West market was. The rows in Table 5 indicate the effects of a particular market on all markets. It is evident that the Outer South East market is again one of the most influential markets among the UK regional property markets, influencing all UK property markets except West Midlands, North and North West. The least influential markets in the long run are South West and North property markets. These property markets do not Granger cause any of the UK property markets. London, East Anglia and North West markets are highly influential, each Granger causing three regional markets.

	LON	OSE	EA	SW	EM	WM	YH	N	NW	Causes
LON	-	13.0826	2.1531	4.0466	6.3833	10.5701	17.5950	23.6265	7.2994	
	-	(0.0417)	(0.9051)	(0.6704)	(0.3817)	(0.1026)	(0.0073)	(0.0006)	(0.2940)	3
OSE	14.2102	-	25.6396	25.8728	17.9038	8.3586	29.0607	5.3387	0.7333	
	(0.0274)	-	(0.0003)	(0.0002)	(0.0065)	(0.2130)	(0.0001)	(0.5012)	(0.9937)	5
EA	3.6596	4.2396	-	13.4825	8.3932	3.4767	17.5250	10.9195	2.0761	
	(0.7226)	(0.6443)	-	(0.0360)	(0.2107)	(0.7471)	(0.0075)	(0.0909)	(0.9126)	3
SW	6.9844	4.3356	2.7013	-	6.1261	8.0445	4.3874	4.5348	4.4814	
	(0.3223)	(0.6314)	(0.8453)	-	(0.4092)	(0.2349)	(0.6244)	(0.6047)	(0.6118)	0
EM	4.8107	2.3387	2.9230	5.8070	-	3.4704	1.8343	7.0035	15.8480	
	(0.5683)	(0.8861)	(0.8184)	(0.4452)	-	(0.7479)	(0.9343)	(0.3205)	(0.0146)	1
WM	0.8904	1.6352	1.6669	4.4268	19.4361	-	3.6261	6.3184	21.6935	
	(0.9894)	(0.9500)	(0.9476)	(0.6191)	(0.0035)	-	(0.7271)	(0.3885)	(0.0014)	2
YH	6.6191	10.7853	4.8939	8.2383	4.7050	13.0463	-	7.5418	9.7754	
	(0.3575)	(0.0952)	(0.5575)	(0.2212)	(0.5822)	(0.0423)	-	(0.2736)	(0.1344)	2
N	4.2633	3.8498	7.0390	4.3456	7.0467	5.7117	10.3694	-	6.1103	
	(0.6411)	(0.6970)	(0.3173)	(0.6300)	(0.3165)	(0.4562)	(0.1099)	-	(0.4110)	0
NW	5.0729	13.6659	10.6286	11.4631	0.2585	5.4458	5.7928	26.4811	-	
	(0.5345)	(0.0336)	(0.1006)	(0.0751)	(0.9997)	(0.4880)	(0.4468)	(0.0002)	-	3
Caused	1	3	1	3	2	1	3	3	2	19

Notes: Unbracketed figures in table are Wald statistics for Granger non-causality tests. Figures in brackets are *p*-values. The level VARs are estimated with lag order of p = k + dmax; k is selected by the LR test in (5) and dmax is set to one. Tests indicate Granger causality by row to column and Granger caused by column to row. For example Outer South-East (OSE) Granger causes all property markets with the exception of West Midlands (WM), North (N) and North West (NW) and is Granger-caused by London (LON), Yorkshire and Humberside (YH) and North West (NW).

Table V. Long-run causality tests by level VAR for UK property markets, 1976-2001

Table VI presents the decomposition of the forecast error variance for one, two, three and four quarter ahead horizons for the UK property markets. An average forecast error variance across these horizons is also included for each market (AVG), while the final column (OTH) sums the percentage of forecast error variance of each market explained by all other UK property markets other then the market itself. The final row (ALL) averages the percentage of forecast variance for each market across itself and all other markets in all forecast time periods. Each row in Table VI indicates the percentage of forecast error variance explained by the column heading for the market indicated in the first column. For example, at the first-quarter horizon, the variance in the Outer South East market is completely explained by its own innovations (100.00 percent), whereas in the remaining markets some percentage of variance is explained by innovations in other markets. For example, in the London market 31.21 percent of variance is explained by its own innovations, while in the North regional property market 66.26 percent is explained by variations in itself. At the first-quarter horizon, other UK property markets explain 68.79 percent of variance in the London market, 79.05 for South West, 57.70 for West Midlands, 59.28 for Yorkshire and Humberside, 33.74 for North, and 42.44 for North West. These would indicate that the Outer South-East property market is the least influenced by innovation in other UK property markets in the first quarter forecast period, while the South West property market is the most sensitive. Overall, markets rather than 'home' markets explain some 50.72 percent of variance in the UK property markets. At one extreme, Outer South-East explains some 56.85 percent of the variance in all other regional markets, while at the other West Midlands and East Anglia explain just 10.26 and 0.63 percent of regional variance, respectively.

MKT	PER	ERROR	LON	OSE	EA	SW	EM	WM	YH	N	NW	OTH
LON	1	24.2335	31.2123	67.9125	0.0000	0.0000	0.0000	0.3497	0.0000	0.0000	0.5256	68.7877
	2	25.0112	29.4487	69.1015	0.0010	0.0662	0.3070	0.3390	0.0234	0.1881	0.5251	70.5513
	3	25.0521	29.3581	69.1479	0.0054	0.0737	0.3197	0.3420	0.0309	0.1970	0.5252	70.6419
	4	25.0541	29.3541	69.1491	0.0055	0.0738	0.3209	0.3425	0.0312	0.1975	0.5254	70.6459
	AVG		29.8433	68.8277	0.0030	0.0534	0.2369	0.3433	0.0214	0.1457	0.5253	70.1567
OSE	1	21.7662	0.0000	100.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	2	22.5823	0.0000	99.0431	0.2552	0.0973	0.1835	0.0010	0.0197	0.2050	0.1952	0.9569
	3	22.6284	0.0007	98.9765	0.2624	0.1008	0.2127	0.0159	0.0232	0.2076	0.2002	1.0235
	4	22.6309	0.0015	98.9689	0.2628	0.1011	0.2143	0.0180	0.0236	0.2085	0.2011	1.0311
	AVG		0.0005	99.2471	0.1951	0.0748	0.1526	0.0087	0.0166	0.1553	0.1491	0.7529
EA	1	25.1050	0.2364	68.3524	31.2361	0.0000	0.0000	0.1749	0.0000	0.0000	0.0001	68.7639
	2	25.8970	0.2234	69.7222	29.3752	0.0438	0.4269	0.1688	0.0011	0.0091	0.0293	70.6248
	3	25.9423	0.2267	69.7373	29.2891	0.0534	0.4367	0.1790	0.0088	0.0268	0.0422	70.7109
	4	25.9445	0.2271	69.7371	29.2842	0.0535	0.4390	0.1807	0.0090	0.0270	0.0426	70.7158
	AVG		0.2284	69.3872	29.7961	0.0377	0.3256	0.1759	0.0047	0.0157	0.0286	70.2039
SW	1	20.3389	0.0237	72.5583	1.4063	20.9465	0.0000	4.9342	0.0000	0.0000	0.1310	79.0535
	2	21.0450	0.0363	73.5457	1.4669	19.9365	0.0806	4.6098	0.1661	0.0331	0.1250	80.0635
	3	21.0823	0.0405	73.5903	1.4650	19.8681	0.0965	4.5937	0.1662	0.0470	0.1327	80.1319
	4	21.0844	0.0406	73.5917	1.4651	19.8646	0.0977	4.5936	0.1666	0.0473	0.1329	80.1354
	AVG		0.0353	73.3215	1.4508	20.1539	0.0687	4.6828	0.1247	0.0318	0.1304	79.8461
EM	1	16.9191	1.6977	50.6737	1.7156	0.0106	34.6451	10.8268	0.0000	0.0000	0.4305	65.3549
	2	17.8755	2.0170	53.5366	1.5395	0.0185	31.2650	10.9689	0.2294	0.0379	0.3872	68.7350
	3	17.9395	2.0136	53.7233	1.5881	0.0523	31.0425	10.8965	0.2372	0.0544	0.3921	68.9576
	4	17.9432	2.0129	53.7385	1.5878	0.0523	31.0326	10.8920	0.2371	0.0545	0.3923	68.9674
	AVG		1.9353	52.9180	1.6077	0.0334	31.9963	10.8960	0.1759	0.0367	0.4006	68.0037
WM	1	15.4882	0.0000	57.6991	0.0000	0.0000	0.0000	42.3010	0.0000	0.0000	0.0000	57.6991
	2	16.0512	0.1630	59.4929	0.1039	0.2039	0.0003	39.9501	0.0285	0.0130	0.0444	60.0499
	3	16.0887	0.1641	59.6305	0.1106	0.2085	0.0040	39.7883	0.0286	0.0201	0.0454	60.2117
	4	16.0911	0.1641	59.6401	0.1113	0.2089	0.0047	39.7764	0.0287	0.0203	0.0455	60.2236
	AVG		0.1228	59.1156	0.0815	0.1553	0.0023	40.4539	0.0215	0.0134	0.0338	59.5461
YH	1	17.6387	1.9983	29.4029	1.0285	1.3886	5.5663	12.6028	40.7156	0.0000	7.2970	59.2844
	2	18.3161	2.6575	31.9150	1.2797	1.3454	5.1972	13.0316	37.7997	0.0021	6.7718	62.2003
	3	18.3627	2.6736	32.1805	1.2936	1.3440	5.1734	12.9857	37.6084	0.0022	6.7385	62.3916
	4	18.3657	2.6730	32.1988	1.2947	1.3441	5.1723	12.9814	37.5961	0.0026	6.7369	62.4039
	AVG		2.5006	31.4243	1.2241	1.3555	5.2773	12.9004	38.4300	0.0017	6.8861	61.5700
N	1	16.8214	0.3663	13.3530	0.7032	2.4665	3.4785	6.7642	0.6841	66.2585	5.9256	33.7415
	2	17.1791	0.5271	13.5504	1.0166	2.3666	3.3412	7.7055	0.6592	63.9025	6.9310	36.0975
	3	17.2050	0.5266	13.5888	1.0176	2.3737	3.3646	7.8283	0.6577	63.7319	6.9108	36.2681
	4	17.2071	0.5285	13.5994	1.0174	2.3732	3.3639	7.8323	0.6578	63.7172	6.9104	36.2829
	AVG		0.4871	13.5229	0.9387	2.3950	3.3870	7.5326	0.6647	64.4025	6.6694	35.5975
NW	1	12.9096	0.0000	29.2520	0.0000	0.0000	0.0000	13.1838	0.0000	0.0000	57.5642	42.4358
	2	13.4295	0.0583	29.1370	0.0861	0.3108	0.4648	16.0052	0.0312	0.3560	53.5505	46.4495
	3	13.4704	0.0782	29.2725	0.0891	0.3106	0.4649	16.1341	0.0330	0.3552	53.2626	46.7374
	4	13.4737	0.0796	29.2900	0.0899	0.3118	0.4653	16.1376	0.0330	0.3556	53.2373	46.7627
	AVG		0.0540	29.2379	0.0663	0.2333	0.3487	15.3652	0.0243	0.2667	54.4037	45.5963
ALL	1-4		5.5445	56.8503	0.6296	2.7243	4.6294	10.2621	4.3887	7.2449	7.7262	50.7249

Notes: The final column (OTH) is the percentage of forecast error variance of the market indicated in the first column (MKT) explained by all UK property markets except the market's own innovations; the periods (PER) in the second column are in quarters. The ordering for the variance decomposition is based on the number of 'causes' in Table 4, i.e. OSE, WM, NW, LON, EA, SW, EM, YH and N. 'AVG' is the arithmetic mean of the four quarter horizons. 'ALL' in the final row is the average forecast error variance explained by the market in the first row across all markets and forecast horizons.

Table VI. Generalised variance decomposition for UK property markets, 1976-2001

Nonetheless, all the property markets included in the analysis are relatively isolated from each other at the 1-quarter horizon period. This is consistent with the lack of liquidity and the comparatively slow diffusion of information in property markets. However, within a 3-month forecast horizon period most of the variance that will ever be explained in any property market, whether through its own innovations or though other market innovations, has occurred. This suggests that there are lags in the transmission of information among property markets, though they are certainly less than what could normally be expected. Once again, the most influential property market is the Outer South-East with some 56.85 percent of forecast error variance across all markets and forecast horizons. The next most influential property markets in terms of forecast error variance are West Midlands (10.26%), North West (7.73%) and North (7.24). The least influential markets are the South West (2.72%) and East Anglia (0.63%).

CONCLUDING REMARKS

This paper investigates long-term and short-term relationships among eight major painting markets and the global equity market during the period 1976 to 2001. Multivariate cointegrating techniques are used to establish relationships among these markets; Granger non-causality tests within an error-correcting model (ECM) are used to measure causal relationships in the short-term, while Wald test statistics in a level VAR approach are used to measure long-run causality. The results indicate, as expected, that the property markets are highly integrated and that there are a large number of significant causal linkages in the long run among UK regional property markets.

The findings obtained in this paper have obvious implications, amongst other things, for the purported benefits of portfolio diversification among the several alternative property markets. In effect, the presence of long-run cointegrating relationships among the several regional markets indicates that the expected returns from such a strategy may not be as great as expected. However, the results also suggest that opportunities for geographic diversification may still exist. For example, in the short run there are comparatively few significant causal linkages between the regional property markets; unfortunately, the significant transaction costs associated with the rebalancing of property portfolios would generally prevent such diversification benefits from being realised.

Nonetheless, the decomposition of variance analysis indicates that a distinguishing characteristic of at least some UK regional property markets is the extremely low level of variance explained by other markets. One average, other property markets explain no more than fifty percent of the forecast error variance across all horizon periods. However, the Outer South-East region is very isolated from other UK regional property markets with less than one percent of variance on average explained from outside the region and, to a lesser extent, so is the Northwest and North regions, with 46 and 36 percent respectively. Combining any of these three regional markets with any of the remaining markets would then provide diversification benefits in a domestic within-property portfolio.

Further, the results of this analysis also provide useful information for modelling price discovery in the UK regional markets. As the most influential market, in terms of both pairwise causation and its share of variance in other markets, the Outer South-East is obviously a clear indicator of trends in property returns throughout the United Kingdom. This lies in stark contrast to East Anglia and the Southwest, which are the least influential. Future work in this area could readily take advantage of these findings to provide more accurate forecasts of prices (and hence returns). Granger-causality tests also indicate that the modelling of price discovery in UK regional property is also likely to encompass a number of feedback relationships (i.e. where two markets are associated with significant causal effects with each other). This indicates that modelling price determination in regional property markets is likely to require the use of techniques that encompass both exogenous and endogenous variables.

REFERENCES

Brown, R.J., Li, L.H. and Lusht, K. (2000) A note on intracity geographic diversification of real estate portfolios: Evidence from Hong Kong, *Journal of Real Estate Portfolio Management*, 6(2), 131-140.

Chandrashekaran, V. (1999) Time series properties and diversification benefits of REIT returns, *Journal of Real Estate Research*, 17(1-2), 91-112.

Cheng, P. and Black, R.T. (1998) Geographic diversification and economic fundamentals in apartment markets: A demand perspective, *Journal of Real Estate Portfolio Management*, 4(2), 93-105.

Cheng, P., Ziobrowski, A.J., Caines, R.W. and Ziobrowski, B.J. (1999) Uncertainty and foreign real estate investment, *Journal of Real Estate Research*, 18(3), 463-479.

De Wit, D.P.M. (1997) Real estate diversification benefits, *Journal of Real Estate Research*, 14(1-2), 117-135.

Eichholtz, P., Huisman, R., Koedijk, K. and Schuin, L. (1998) Continental factors in international real estate returns, *Real Estate Economics*, 26(3), 493-509.

Eichholtz, P., Koedijk, K. and Schweitzer, M. (2001) Global property investment and the costs of international diversification, *Journal of International Money and Finance*, 20(3), 349-366.

Engle, R. F. and Granger, C.W.J. (1987) Co-integration and Error Correction: Representation, Estimation, and Testing, *Econometrica*, 55, 251–276.

Giliberto, M., Hamelink, F., Hoesli, M. and MacGregor, B. (1999) Optimal diversification within mixed-asset portfolios using a conditional heteroskedasticity approach: Evidence from the U.S. and U.K., *Journal of Real Estate Management*, 5(1), 31-45.

Gordon, J.N., Canter, T.A. and Webb, J.R. (1998) The effect of international real estate securities on portfolio diversification, *Journal of Real Estate Portfolio Management*, 4(2), 83-91.

Graff, R.A. and Young, M.S. (1996) Real estate return correlations: Real world limitations on relationships inferred from NCREIF data, *Journal of Real Estate Finance and Economics*, 13(2), 121-142.

Granger, C. W. .J. (1969) Investigating Causal Relations by Econometric Models and Cross-Spectral Methods, *Econometrica*, 37(3), 424–438.

Hartzell, D., Hekman, J. and Miles, M. (1986) Diversification categories in investment real estate, *Journal of American Real Estate and Urban Economics Association*, 14(2), 230-254.

Hoesli, M. et al (1997) The spatial dimensions of the investment performances of the English commercial property, *Urban Studies*, 34(9), 1475-1519.**(??)**

Johansen, S. (1991) Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models, *Econometrica*, 59(6), 1551–1580.

Johansen, S. and K. Juselius (1990) Maximum Likelihood Estimation and Inferences on Cointegration – With Applications to the Demand for Money, *Oxford Bulletin of Economics and Statistics*, 52, 169–210.

Lins, D.A., Sherrick, B.J. and Venigalla, A. (1992) Institutional portfolio: Diversification through farmland and investment, *Journal of American Real Estate and Urban Economics Association*, 20(4), 549-571.

Liu, C.H. and Mei, J. (1998) The predictability of international real estate markets, exchange rate risks and diversification consequences, *Real Estate Economics*, 26(1), 3-37.

Lizieri, C. and Finlay, L. (1995) International property portfolio strategies problems and opportunities, *Journal of Property Valuation and Investment*, 13(1), 6-21.

MacKinnon, J.G. (1991) Critical Values for Cointegration Tests, in R.F.Engle and C.W.J. Granger (eds), *Long-run Economic Relationships: Readings in Cointegration*, Oxford University Press, New York.

Masih, A.M.M. and Masih, R. (1999) Are Asian stock market fluctuations due mainly to intra-regional contagion effects? Evidence based on Asian emerging stock markets, *Pacific Basin Finance Journal*, 7(3-4), 251–282.

Quan, D.C. and Titman, S. (1999) Do real estate prices and stock prices move together? An international analysis, *Real Estate Economics*, 27(2), 183-207.

Rubens, J.H., Louton, D.A. and Yobaccio, E.J. (1998) Measuring the significance of diversification gains, *Journal of Real Estate Research*, 16(1), 73-86.

Seiler, M.J., Webb, J.R. and Myer, F.C.N. (1999) Diversification issues in real estate investment, *Journal of Real Estate Literature*, 7(20), 163-179.

Sivitanides, P.S. (1996) Property-type diversification in real estate portfolios: Multi-period return measures vs single-period return measures, 2(2), 127-140.

Stevenson, S. (2000) International real estate diversification: Empirical tests using hedging indices, *Journal of Real Estate Research*, 19(1-2), 105-131.

Toda, H.Y. and Yamamoto, T. (1995) Statistical Inference in Vector Autoregressions with Possibly Integrated Processes, *Journal of Econometrics*, 66, 225–250.

Tuluca, S.A., Myer, F.C.N. and Webb, J.R. (2000) Dynamics of private and public real estate markets, *Journal of Real Estate Finance and Economics*, 21(3), 279-296.

Viezer, T.W. (2000) Evaluating “within real estate” diversification strategies, *Journal of Real Estate Portfolio Management*, 6(1), 75-95.

Williams, J.E. (1996) Real estate portfolio diversification and performance of the twenty largest MSAs, *Journal of Real Estate Portfolio Management*, 2(1), 19-30.

Wilson, P.J. and Okunev, J. (1999) Long-term dependencies and long run non-periodic co-cycles: Real estate and stock markets, *Journal of Real Estate Research*, 18(2), 257-278.

Wolverton, M.L., Cheng, P. and Hardin, W.G. (1998) Real estate portfolio risk reduction through intracity diversification, *Journal of Real Estate Portfolio Management*, 4(1), 35-41.